VANADIUM MINING IN THE CARRIZO MOUNTAINS, 1942-1947, SAN JUAN COUNTY NEW MEXICO, AND APACHE COUNTY, ARIZONA

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ILLUSTRATIONS

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ABSTRACT

During the late 1930's and early 1940's, the U.S. Department of the Interior issued six leases to mine carnotite ores in the Carrizo Mountains on the Navajo Indian Reservation, in San Juan County, New Mexico and Apache County, Arizona. The carnotite deposits, containing uranium and vanadium, occurred in the Salt Wash Member of the Morrison Formation which crops out around the perimeter of the Carrizo Mountains. The vanadium oxide (V_2O_5) in the ores was recovered at plants in Monticello, Utah and Durango, Colorado. Vanadium was in demand by the federal government for use in the hardening of steel for war armaments. The operating companies were the Vanadium Corporation of America, Curran Brothers and Wade, and Wade, Curran and Company. Thirty-eight separate properties produced a total of 21,433 tons of ore averaging 2.35 percent V_2O_5 and containing 1,006,981 pounds V_2O_5 between 1942 and 1947. These ores had a total value of $390,315.51. An estimated 76,000 pounds U_3O_8 were secretly recovered from the ores by the Manhattan Project for use in the first atomic weapons.

INTRODUCTION

During the early and middle 1940's the carnotite deposits in the Salt Wash Member of the Morrison Formation, in the Carrizo Mountains, were extensively mined for their vanadium content. Uranium in the ores was recovered for the Manhattan Project. Very little factual information on this activity has been published, and some is incorrect. For example, a recent paper by Finch and McLemore (1989) states that the ore was shipped to Durango, Colorado, when in fact the majority of the ore was sent to Monticello, Utah for processing. Also, an early report prepared by the U.S. Atomic Energy Commission estimated that vanadium production in the Carrizo Mountains had been approximately 48,000 tons of ore that averaged 2.50 percent V_2O_5 (Fetzer, 1948). This estimate is over twice the amount that was actually produced.

The principal source of data presented here is a detailed report prepared by the General Services Administration (GSA), Indian Trust Accounting Division for the Navajo Tribe. This document (GSA, 1981) was admitted as evidence in U.S. Claims Court, Navajo Tribe vs. United States, Docket Nos. 69 and 299 (copper, vanadium, uranium, sand, rock and gravel claims) held in Albuquerque, New Mexico, February 24-March 4, 1983. A copy of the vanadium and uranium section was obtained by the Grand Junction Area Office of the U.S. Department of Energy (DOE), where the author was formerly employed. Details of the mineral leasing regulations, applicable to the Navajo Indian Reservation, were taken from a report prepared by DeVoto and Huber (1982) for the U.S. Department of Justice, which was also admitted as evidence in the above case.

HISTORICAL BACKGROUND

The discovery of radium by Marie and Pierre Curie in 1898 led to the realization that all uranium ores contained this new element. Experiments which showed that radium inhibited the growth of certain cancers so astonished the medical profession that an incentive to mine the uranium-bearing ores was created.

Shortly before 1910, metallurgical processes for relatively large-scale recoveries of radium from carnotite ores were perfected. The improved processes resulted in greatly increased demands for carnotite and in accelerated prospecting in southern Colorado. About one gram of radium is present in every 200 to 300 tons of ore containing 2.0 percent U_3O_8.

Shortly after 1910, the carnotite deposits in southwestern Colorado and southeastern Utah became one of the principal world sources of radium (Tyler, 1930). For about 12 years, these deposits were mined for radium and yielded some byproduct uranium and vanadium. This activity lead to prospecting and the discovery of similar deposits in the Carrizo Mountains of northwestern New Mexico and northeastern Arizona (Figure 1).

GEOLOGIC SETTING OF THE CARNOTITE DEPOSITS

Nearly all the carnotite deposits in southwestern Colorado and the adjacent parts of Utah, Arizona, and New Mexico occur in the Salt Wash Member of the Morrison Formation of Late Jurassic age. In the 1910's and 1920's this unit was included in the McElmo Formation, a name now abandoned. Several carnotite deposits were known in the Triassic Chinle Formation, but only a few were mined in the 1920's.

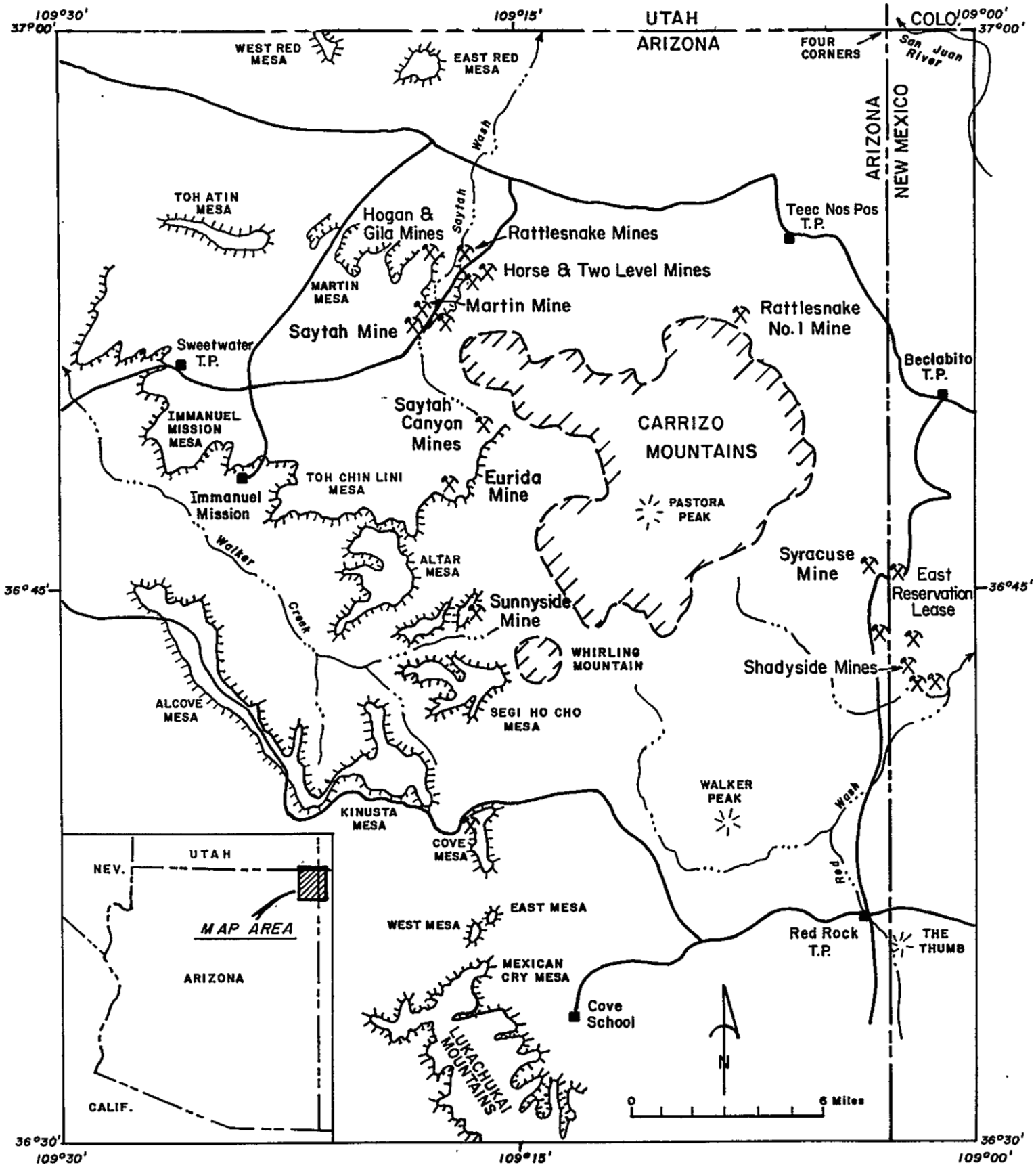

Figure 1. Index map of the Carrizo Mountains showing the location of the vanadium mines that operated in the 1940's

The Salt Wash Member is exposed around the perimeter of the Carrizo Mountains in northeastern Apache County, Arizona, and in the extreme northwestern corner of San Juan County, New Mexico. The mountains consist of an irregularly shaped 68-Ma (Armstrong, 1969) intrusive mass composed of a central stock and several sills of light-gray diorite porphyry that have been injected laterally into the surrounding sedimentary rocks. The mountains are about 13 miles in diameter and rise 2,000-3,000 feet above the surrounding plain. Pastora Peak, elevation 9,420 feet, is the highest point (Figure 1). On the east side of the Carrizo Mountains the Salt Wash Member crops out as a belt from Red Rock to Beclabito roughly paralleling the Arizona-New Mexico state line; south of Beclabito it rims Beclabito dome. West of the dome, a narrow band of Salt Wash Member is exposed on the margin of the intrusion. On the north side of the Carrizo Mountains there is a large exposure of the upper Salt Wash Member southwest of the Four Corners area. The lower Salt Wash is exposed in a small area at the foot of the mountains and in separate exposures interbedded with igneous sills in the northeastern part of the intrusive complex. The Toh Atin anticline exposes the lower Salt Wash Member in the northwest Carrizos at Martin Mesa. The large amount of Salt Wash Member north of the Toh Atin anticline is largely covered with dune sand, and the lower Salt Wash Member is also exposed near the Utah state line. West and south of the Carrizo Mountains the Salt Wash Member caps numerous mesas. In the central part of the Carrizo Mountains, discontinuous outcrops of Salt Wash Member occur within the intrusive sills.

In the Carrizo Mountains the Salt Wash Member consists of 180-250 feet of fluvial, light tan to white, fine-grained sandstone with interbedded, thin beds and lenses of gray, grayish-green and reddish-gray mudstone. The mudstone comprises from 5 to 30 percent of the member.

The uranium-vanadium orebodies are formed by the selective impregnation of the sandstone and adsorption by the mudstone and fossil plant material. Orebodies are commonly associated with detrital plant fragments in the sandstone. The orebodies are roughly tabular in cross-section and irregular in plan. They range from several feet in width to a few hundred feet in length. Thicknesses range from a feather edge to up to ten feet. Small high-grade pods of ore are associated with replaced fossil wood. Throughout the Carrizo Mountains the uranium mineralization occurs at various stratigraphic horizons in the Salt Wash Member; however, the orebodies are always found in the lower one-half of the member.

The bright yellow mineral carnotite, a potassium uranium vanadate, has given the deposits their name. Later work by Corey (1956,1958) and S. R. Austin (written communication, 1967) have identified tyuyamunite, a calcium uranium vanadate, and meta-tyuyamunite as the only uranium minerals in the Carrizo deposits. Vanadium clay and montroseite are present. These minerals have been oxidized to form a number of secondary vanadium minerals that include sherwoodite, duttonite(?), hewettite, metahewettite, rossite, metarossite, and hendersonite (Corey, 1958). Calcite is a common cement in ore. Pyrite, iron oxides, and gypsum may also

be present. The ore grades range from 0.10 to more than 0.50 percent U_3O_8 and from 1.00 to 10.00 percent V_2O_5.

EARLY PROSPECTING AND LEASING

Outcrops containing uranium and vanadium minerals in the Carrizo Mountains were discovered by John F. Wade about 1918 (oral communication, 1955). Wade of Farmington, New Mexico, operated Sweetwater Trading Post in the western Carrizo Mountains. The newly discovered deposits could not be mined because the Navajo Indian Reservation was closed to prospecting and mining. A Congressional Act of June 30, 1919, opened the Navajo Indian Reservation to prospecting and locating mining claims in the same manner as prescribed by the United States Mining Law of 1872. This Act allowed prospectors to enter the Reservation and stake a mining claim if their prospecting located promising mineralization. The locator of the claim then obtained a lease on this land under terms that included escalating advance royalties and rentals, and annual work commitments.

During the 1920's the Office of Indian Affairs (later changed to Bureau of Indian Affairs), U.S. Department of the Interior, issued four leases for metal mining in the Carrizo Mountins (GSA, 1981). Three of these leases were for carnotite mining. A fourth lease, located in the northeastern Carrizo Mountains is believed to have been for copper. The lease of the Radium Ores Company, in the northwestern Carrizo Mountains, produced 40,000 pounds of radium ore in November 1920 (GSA, 1981). This is the only recorded radium production from the Carrizo Mountains.

Carriso Uranium Company

After the Navajo Indian Reservation was opened to prospecting and mining, John F. Wade, who was also associated with the Radium Ores Company, located 40 claims astride the Arizona - New Mexico state line in the vicinity of Milepost 16 (oral communication, 1955). The GSA (1981) could not locate the details of the Carriso Uranium Company's lease, except for the first year's rental on 177.45 acres paid in May, 1922, and noted that no production was recorded.

In April, 1921 the area was examined by W. H. Staver, a consulting mining engineer. Staver (1921) noted that the company's holding consisted of the South Butte, Bluebell, North Star, and Hilltop claim groups. The North Star Group was located astride the state line, with five claims in New Mexico and six claims in Arizona, and contained the only development. Thirty-seven sacks of high-grade ore from these claims were stored at Beclabito Trading Post (Figure 1). Staver estimated that a total of 2,900 tons of probable ore could be developed on the property. Butler and Allen (1921) mention that 500 feet of benching and 100 feet underground development had been done on the claims. Hess (1924) also visited the area of the Carriso Uranium Company's activities in 1921 and reported that no shipments had been made, and that the ore was richer in vanadium than in uranium. In 1926, Hess (1929) reported that the Utah Vanadium Company obtained some ore from the Carrizo Mountains and the ore was shipped to Denver for the production of fused vanadium oxide used by eastern ferroalloy manufacturers. Although there are no details

on the size of this shipment it represents the first vanadium production from the Carrizo Mountains. The shipment no doubt included the sacked ore observed by Staver at Beclabito, five years earlier.

Later Developments.

On March 25, 1936, the Secretary of the Interior closed the Navajo Indian Reservation to claim location and prospecting for minerals until further authorization. In July 1936, an application to prospect was made to the Executive Committee of the Navajo Tribal Council. The application asked the council to pass a resolution requesting the Secretary of the Interior to open the Navajo Reservation for mining to the applicant. The resolution was rejected by the Executive Committee, which evidently did not want prospecting or mining on the Reservation at that time.

THE VANADIUM MARKET

By the mid-1930's, the mines in the carnotite region of southwestern Colorado and southeastern Utah were being reopened for their vanadium content. At the same time, the Secretary of the Interior was being asked to open the Navajo Indian Reservation for prospecting and mining.

When the United States entered World War II the need for vanadium for the steel industry greatly increased. Due to the uncertainty of foreign supplies and the need for vanadium for war armaments, the Federal government formed Metals Reserve Company in December 1941. This agency, which was part of the Reconstruc-

tion Finance Corporation, began an ore-purchasing program and increased the base price paid for vanadium ore.

Monticello, Utah

In late 1940, Vanadium Corporation of America (VCA) opened a vanadium ore-buying station at Monticello, Utah, in order to stimulate mining in the area. Within a short time, ore production increased sufficiently to justify construction of a vanadium mill. In September 1941, the War Production Board approved VCA's proposal to build a mill. Funding was provided through the government's Defense Plant Corporation. The plant was to be operated by VCA for Metals Reserve. Actual construction started in February, and on August 24, 1942, the first vanadium was produced (Albrethsen and McGinley, 1982, p. 92).

In April 1942, while construction was under way, the Metals Reserve Company (MRC) established an ore-buying station at Monticello, and appointed the United States Vanadium Corporation (USV) as its buying agent. All ore producers, VCA, USV and independents, sold ore to the MRC. MRC in turn had the ore milled by VCA or other mills. Metals Reserve closed the Monticello mill in February 1944 when the government had acquired adequate vanadium stocks.

In 1945, VCA leased the Monticello mill from the Defense Plant Corporation and purchased the remaining ore stockpiles from MRC. VCA processed the stockpiled ore plus ore from other sources until the mill closed again in 1946 (Albrethsen and McGinley, 1982, p. 92). During the time the Monticello mill was

operating, VCA shipped all of its Carrizo Mountains production to this plant (GSA, 1981).

Durango, Colorado

In 1942, the Reconstruction Finance Corporation contracted with United States Vanadium Corporation (USV) to convert and operate an old lead smelter for vanadium production. The vanadium was supplied to Metals Reserve Company. USV operated the plant for the government until February 1944, when the government vanadium purchasing program was terminated. USV then purchased the facilities from the Reconstruction Finance Corporation and operated them for the production of vanadium for commercial sales until August 31, 1945, when the plant was closed (Albrethsen and McGinley, 1982, p. A-11). All of the ore produced in the Carrizo Mountains by John Wade's two companies was processed at Durango.

The Metals Reserve Company's vanadium procurement program was the stimulus to revive carnotite mining in the Carrizo Mountains and elsewhere on the Colorado Plateau.

U.S. Geological Investigations

As part of the U.S. Geological Survey's (USGS) investigations of critical war materials, the uranium-vanadium deposits of the Carrizo Mountains were examined during October and November 1942. The USGS geologists examined and mapped the existing mines, acquired production history and statistics from the mine operators, and estimated vanadium ore reserves. The detailed results of the

October-November 1942 investigations are in a report by Duncan and Stokes (1942), which was submitted to the U.S. Army's Manhattan Engineer District. The general geology and the description of the ore deposits was later published by Stokes (1951).

LEASING AND PRODUCTION HISTORY

The Navajo Indian Reservation was opened by a Congressional Act of May 11, 1938, but with new procedures. This Act gave the Tribal Council the authority to enter into leases for the Reservation lands with approval of the Secretary of Interior. Prospectors no longer could enter the Reservation and stake a mining claim under regulations similar to those of the United States Mining Law. The new mining regulations contained escalating annual rentals, a base royalty of 10 percent (mine mouth value), bond requirements, acreage limitations, and a term of 10 years which could be extended by production.

Lease I-149-IND-3798

On December 4, 1939, effective January 19, 1940, John F. Wade, Thomas F. V. Curran, H. R. Redington (d.b.a. Wade, Curran and Co.) leased 65.02 acres in the Carrizo Mountains. Their lease, I-149-IND-3798 covered the Martin Claim, Say-Tah Claim, and the Eurida No. 2 Claim as described in U.S. Mineral Survey Nos. 3701 and 3703. The lease was for a period of five years.

These are three of the properties formerly held by Wade's Radium Ores Company. Shipments from Lease I-149-IND-3798 commenced in August, 1942. The Martin mine was the first to be

developed. When the USGS examined the area in November 1942, approximately 500 tons of ore averaging 2.50 percent V_2O_5 had been produced from the Martin mine (Duncan and Stokes, 1942, p. 23-24). When mining ceased in November 1943, a total of 2,198 tons of ore containing 127,909 pounds V_2O_5 and averaging 2.91 percent V_2O_5 had been produced (Table 1). Ore mined by Wade, Curran and Company was shipped by truck to Farmington, New Mexico and then by rail to the mill at Durango, Colorado. Lease I-149-IND-3798 was due to expire on January 19, 1945 but was apparently cancelled earlier.

Lease I-149-IND-4225

On April 5, 1940, effective May 9, 1940, John F. Wade, Thomas F. V. Curran, and H. R. Redington (d.b.a. Wade, Curran and Co.) leased an additional 42.32 acres in the Carrizo Mountains. This lease, I-149-IND-4225, covered the Sunnyside Lode Claim of 20.66 acres in the western Carrizo's and the Syracuse Lode Claim of 20.66 acres in the eastern Carrizo's (Figure 1). The claims were described by U.S. Mineral Survey Nos. 3700 and 3857. The lease was for a period of five years.

The Sunnyside claim had also been held by Wade's Radium Ores Company. Shipments from Lease I-149-IND-4225 were recorded from late May 1942 through October 1943.

TABLE 1

Vanadium Ore Production, 1942-1947, Carrizo Mountains, San Juan County, New Mexico and Apache County, Arizona.

Lease No. I-149-IND-	Tons of Ore	Pounds V_2O_5	Percent V_2O_5	Years Operated
3798	2,198	127,909	2.91	1942-43
4225	966	84,418	4.37	1942-43
5465	7,504	274,411	1.83	1942-44
5705	10,231	504,822	2.47	1942-45,47
6197	388	15,060	1.94	1943-44
6342	146	361	0.12	1944
Total	21,433	1,006,981	2.35	

Source: 1942-1945; GSA (1981)
1947; USGS memo dated June 2, 1948 (in DOE files)

Shipments from the two claims are not separated, but John Wade (oral communication, 1955) stated that the Syracuse was the first property to be mined. Harshbarger (1946, p. 25) reports that from May through October 1943, shipments from the Sunnyside mine totalled 475 tons of ore containing 24,395 pounds V_2O_5 and averaging 2.57 percent V_2O_5. Total production from this lease was 966 tons of ore containing 84,418 pounds V_2O_5 and averaging 4.37 percent V_2O_5 (Table 1). Ore from this lease was also shipped to Durango, Colorado. Lease I-149-IND-4225 was due to expire on May 9, 1945 but was apparently cancelled earlier.

New Regulations.

On April 9, 1941, the Navajo Tribal Council requested the Secretary of the Interior to lease lands for mining purposes to the highest bidder. In order to take care of this situation, the mining leases were written for large areas and subsequently reduced in acreage at the end of a specified time period. The net effect of this type of lease was that a prospecting permit was issued to the highest bidder, who then had the right to lease land within the permit area up to a maximum acreage. The maximum acreage a company could lease on the Reservation was 960 acres.

Lease I-149-IND-5456.

The first sale to be held under the new bidding regulations was in the northwestern Carrizo Mountains. On November 28, 1941, the Office of Indian Affairs advertised an exploration mining lease sale, for carnotite and related minerals, for 144 square

miles in Apache County, Arizona. The tract was described as: "unsurveyed land which was designated on an unapproved survey as Township 12 and 13 North, Range 7 West, and Township 12 and 13 North, Range 6 West, Navajo Meridian."

Bids were opened on December 19, 1941, at which time two bids were received; VCA, Naturita, Colorado, $2,000.00; and King Lease, Inc., Ouray, Colorado, $100.00 (GSA, 1981, exhibit 26). Lease I-149-IND-5456 was executed with VCA on December 26, 1941, effective February 23, 1942 for a period of ten years. Ore shipments to the Monticello mill commenced in early May 1942 and continued through February 1944.

The early May 1942 shipment from this lease was the first vanadium ore produced in the Carrizo Mountains under the Metals Reserve program. The ore came from the Rattlesnake mines in the Saytah Wash area (Duncan and Stokes, 1942, p. 22). When the operations were examined by the USGS in November 1942, approximately 2,000 tons of ore with an average grade of 1.80 percent V_2O_5 had been produced (Duncan and Stokes, 1942, p. 22).

On September 2, 1943, the lease was reduced to a permanent operating lease and 16 plots (claims) totalling 229.14 acres were selected to be retained. Details of these plots are given in Table 2. These 16 plots were commonly referred to as the "West Reservation Lease" by VCA. When mining stopped in February 1944, total production for lease 1-149-IND-5456 had been 7,504 tons of ore containing 274,411 pounds V_2O_5 and averaging 1.83 percent V_2O_5 (Table 1).

TABLE 2

Location and Size of Plots, Lease I-149-IND-5456.

Number	Mine Name*	Acres	Location
1	Hogan	10.33	Canyon W. of Saytah Wash
2		10.33	Canyon W. of Saytah Wash
3		10.33	Canyon W. of Saytah Wash
4	Gila	10.33	Canyon W. of Saytah Wash
5		10.33	W. side of Saytah Wash
6	Rattlesnake Mines	52.36	E. of Saytah Wash
7	Rattlesnake No. 5	2.14	E. side of Saytah Wash
8		10.41	Canyon E. of Saytah Wash
9		9.77	Rattlesnake Canyon
10	Horse	10.19	Rattlesnake Canyon
11	Two Level	7.41	Rattlesnake Canyon
12	Rattlesnake No. 8	18.13	E. side Saytah Wash
13		7.92	E. side Saytah Wash
14		20.66	N. Eurida Mesa
15		31.74	S. Eurida Mesa
16		6.76	S.W. Eurida Mesa
	Total	229.14 acres	

* Mining and prospecting occurred on all plots, but only seven have named mines.

Source: Unpublished data, U.S. Atomic Energy Commission, Grand Junction, Colorado office.

Lease I-149-IND-5705.

On May 29, 1942, in response to requests by several mining companies, the Office of Indian Affairs advertised an exploration lease sale for carnotite and related minerals in the eastern Carrizo Mountains. The area offered was described as follows: "beginning at a point on the New Mexico-Arizona State Line which is approximately 8 1/3 miles south of the corner common to the states of Colorado, Utah, New Mexico, and Arizona; thence east 6 miles, thence south 12 miles; thence west 6 miles to the Arizona-New Mexico state line; thence west 3 1/2 miles; thence north 2 miles; thence east one mile; thence north 10 miles; thence east 2 1/2 miles to the Arizona-New Mexico state line and in the point of beginning." The area contained approximately 104 square miles. This was the second carnotite lease sale for Navajo lands held under the bidding procedures.

Bids were opened on June 15, 1942, at which time VCA bid $7,600, and John F. Wade and Thomas F. V. Curran, partners, bid $7,550 (GSA, 1981, exhibit 31). As the bids were nearly equal, and since Wade and Curran offered to pay $2,000 over and above the highest bid received, the General Superintendent of the Navajo Service requested that the Commissioner of Indian Affairs make the decision to award the lease. VCA was awarded the lease I-149-IND-5705, which was executed on July 14, 1942, effective July 23, 1942, for a period of 10 years.

Mining commenced in August 1942 on King Tutt Mesa in San Juan County, New Mexico (Figure 2). When the operations were examined by the USGS in November 1942, approximately 1,800 tons of ore with an average grade of 2.30 percent V_2O_5 had been

produced (Duncan and Stokes, 1942, p. 26). Lease I-149-IND-5705 was commonly referred to as the "East Reservation Lease" by VCA. The USGS referred to the mines as the Eastside mines, a name still used in current USGS reports.

On September 2, 1943, the lease was reduced to a permanent operating lease and 12 plots totalling 436.79 acres were selected to be retained. Six of the plots (1-6) were on King Tutt Mesa, two of the plots (7, 10) were along the north side of Oak Creek Canyon and the remaining four plots (8, 9, 11, and 12) were in the vicinity of Milepost 16. Each of the plots were named by VCA (Table 3).

Three of the plots near Milepost 16 (9, 11, and 12) covered the remainder of the area previously developed by the Carriso Uranium Company on its North Star claims.

Mining continued through August 1944. Single shipments were recorded in February 1945 and in July 1947. Total production from Lease I-149-IND-5705 was 10,231 tons of ore containing 504,822 pounds V_2O_5 and averaging 2.47 percent V_2O_5 (Table 1). With the exception of the 1947 shipment which was made to its mill at Naturita, Colorado, VCA shipped ore from this lease to Monticello, Utah. All but a few dozen tons, mined on Plots 10, 11 and 12, were mined in New Mexico.

Lease I-149-IND-6197.

On July 21, 1943, in response to requests from mining companies, the Office of Indian Affairs advertised an exploration

Figure 2, Navajo miners at the Shadyside area, King Tutt Mesa, San Juan County, New Mexico. Note stacked ore above pit, ready for shipment, November 1942. Photo by USGS.

TABLE 3

Location, Name and Size of Plots, Lease I-149-IND-5705.

Number	Mine Name	Acres	Location
1	Red Wash Point	3.53	S.E. King Tutt Mesa
2	King Tutt Point	9.14	S.W. King Tutt Mesa
3	Shadyside	145.13	Central King Tutt Mesa
4	Williams Point	8.62	N. Central King Tutt Mesa
5	Fissure	1.57	N. Central King Tutt Mesa
6	Franks Point	6.23	N.W. King Tutt Mesa
7	Lower Oak Creek	205.39	Oak Creek Canyon
8	Cottonwood Butte	20.66	Cottonwood Butte
9	Lone Star	6.20	E. of MP-16
10	Oak Springs	5.53	S.E. of Oak Springs
11	White Cap	20.66	S.W. of MP-16
12	Syracuse	4.13	W. of MP-16
	Total	436.79	

All were located in San Juan County, New Mexico except numbers 10, 11, and 12 in Apache County, Arizona.

Source: Unpublished data, U.S. Atomic Energy Commission, Grand Junction, Colorado office.

mining lease sale for carnotite and related minerals in the northern and western Carrizo Mountains. The area offered consisted of 168 square miles in a tract 7 miles wide east-west, and 24 miles long, north-south, with the southeast corner located near Cove School (Figure 1). Excluded were all lands subject to prior approved mineral leases.

Bids were opened on August 3, 1943 at which time the only bid received was $5,085.00 from Thomas F. V. Curran, Charles F. Curran, and John F. Wade, d.b.a. Curran Brothers and Wade (GSA, 1981, exhibit 38). Lease I-149-IND-6197 was executed on August 6, 1943, effective October 27, 1943 for a period of ten years. On the date the lease became effective, a two thirds interest was assigned to United States Vanadium Corporation (USV).

Shipments commenced in December 1943 and continued through February 1944. Total production was 388 tons of ore containing 15,060 pounds V_2O_5 and averaging 1.94 percent V_2O_5 (Table 1). The ore was mined from the Saytah Canyon mine and the CB & W Main Claim mine in Saytah Canyon and from the North Martin mine in Saytah Wash. A small amount may have been mined from the west side of Cove Mesa (Harsbarger, 1946, fig. 3).

On March 22, 1944 the lease was reduced to a permanent operating lease with 12 plots, totalling 959.7 acres, selected to be retained. Details of these plots are given in Table 4. Included in this selection were two mines (Martin, Eurida) previously held under Lease I-149-IND-3798. Plots covering the Sunnyside and Syracuse mines were not selected due to the 960 acre limitation on total land that could be held by one organization on the

TABLE 4

Location and Size of Plots, Lease I-149-IND-6197.

Number	Mine Name	Acres	Location
1	Martin	20.2	West side Saytah Wash
2	North Martin	14.4	West side Saytah Wash
3		2.2	East side Saytah Wash
4	Saytah Canyon	10.4	North side Saytah Canyon
5	Main Claim	5.7	South side Saytah Canyon
6	Eurida	20.6	Eurida Mesa
7	Cove Mesa	246.2	South 2/3 Cove Mesa
A		16.0	East end Saytah Canyon
B		17.3	NW point Segi Ho Cho Mesa
C		34.9	SW point Segi Ho Cho Mesa
D		37.8	SW point Segi Ho Cho Mesa
E		529.0	East end Kinusta Mesa
	Total	959.7	

Source: Harshbarger (1946)

Navajo Indian Reservation. Selection and surveying of the plots were done primarily by personnel of the Union Mines Development Corporation. Union Mines was a private contractor to the Army's Corps of Engineers Manhattan Engineer District, who were appraising the uranium resources of the Colorado Plateau (Chenoweth, 1985, 1988). On April 17, 1944, Union Mines acquired Curran Brothers and Wade's one-third interest in the lease, and on April 24, 1944 they acquired USV's two-thirds interest. Both reassignments were approved by the Office of Indian Affairs on October 31, 1944 (GSA, 1981).

The cost of acquiring the lease was reported at $16,000 or about $16.50 an acre (Manhattan Engineer District, 1947, p. 2-6). Union Mines did no physical exploration or mining on the lease, a planned drilling project was never approved by the Manhattan District Engineers. The lease was reassigned to the U.S. Atomic Energy Commission in 1948.

Lease I-149-IND-6342.

In the fall of 1943, Navajo prospectors located vanadium-bearing outcrops of the Salt Wash sandstone about three miles southwest of Teec Nos Pos Trading Post (Figure 1).

VCA asked the Office of Indian Affairs that a 13.50 acre tract was advertised on January 11, 1944, and when the bids were opened on February 1, 1944, VCA was the only bidder with a bonus bid of $600.00. (GSA, 1981)

Lease I-149-IND-6342 was executed on February 8, 1944, effective April 1, 1944. VCA named the lease Rattlesnake No. 1

Lease produced 146 tons of ore containing 361 pounds V_2O_5 and averaging 0.12 percent V_2O_5 (Table 1). Since the Metals Reserve program had terminated in February 1944, this ore was trucked to VCA's vanadium mill at Naturita, Colorado.

MANHATTAN ENGINEER DISTRICT ACTIVITIES

In 1942, the Army Corps of Engineers formed the Manhattan Engineer District (MED) for the development of atomic weapons and the acquisition of raw materials for the production of weapons. The entire Manhattan Project was dependent on the acquisition of uranium. At the operating vanadium mills in the carnotite region of the Colorado Plateau - Monticello, Utah; Durango, Naturita, and Uravan, Colorado - MED made arrangements to secretly recover uranium from the carnotite ores and from the tailings from prior operations (Chenoweth, 1985, 1988).

Using the uranium (U_3O_8) to vanadium (V_2O_5) ratios of ore shipments from these same mines that were made in 1948-1953 under the U.S. Atomic Energy Commission's ore procurement program, I estimated that the Carrizo vanadium ores contained 108,627 pounds U_3O_8 (Table 5). MED's uranium procurement program on the Colorado Plateau ended in 1945. Hence, the 1947 shipment from Lease I-149-IND-5705 was not included. Also, the small shipment from Lease I-149-IND-6342 was too low grade to be considered for uranium recovery. Assuming a 70 percent milling recovery factor, it is reasonable to estimate that approximately 76,000 pounds U_3O_8 were recovered from the Carrizo vanadium ores.

In addition to MED's uranium procurement program, a contractor

TABLE 5

Estimated Uranium Content of the Vanadium Ores, Carrizo Mountains, 1942-1945.

Lease No. I-149-IND-	Pounds V_2O_5	U_3O_8 to V_2O_5 Ratio*	Estimated Pounds U_3O_8
3798	127,909	1:7.5	17,055
4225	84,418	1:9.3	9,077
5465	274,411	1:9.0	30,490
5705	504,199	1:10	50,420
6197	15,060	1:9.5	1,585
		Total contained pounds	108,627

* Based on 1948-1953 production purchased by the U.S. Atomic Energy Commission

Source: Chenoweth (1985, 1988)

Union Mines Development Corporation, made geologic studies of the uranium resources of the Salt Wash Member of the Morrison Formation and acquired land for developing uranium reserves throughout the Colorado Plateau (Manhattan District Engineers, 1947). Union Mines' activities in the Carrizo Mountains are summarized in reports by Coleman (1944) and Harshbarger (1946).

All of the functions of MED, and the numerous government-owned facilities associated with these activities, were transferred to the newly formed U.S. Atomic Energy Commission (AEC) by Executive Order 9816, effective midnight December 31, 1946. By mid-1947, the AEC established uranium procurement programs for the continued development of atomic energy for military purposes (Albrethsen and McGinley, 1980).

SUMMARY

The federally funded Metals Reserve ore procurement program, December 1941-February 1944, was a boom to vanadium mining in the carnotite region of the Colorado Plateau, including the Carrizo Mountains. Vanadium was needed by the war effort to harden steel used in armaments. During the period May 1942 through July 1947, 38 properties in the Salt Wash Member of the Morrison Formation, on the perimeter of the Carrizo Mountains produced a total of 21,433 tons of ore averaging 2.35 percent U_3O_8 and containing 1,006,981 pounds V_2O_5 (Tables 6,7). After the Metals Reserve program ceased in February 1944, the mining of vanadium ore all but ended in the Carrizos and elsewhere on the Colorado Plateau.

During the 1942-1947 period, 1,006,981 pounds of vanadium

oxide (V_2O_5) were produced from the mines in the Carrizo Mountains. This material had a total value of $390,315.51, or approximately $0.39 per pound V_2O_5. Royalties paid the Navajo Tribe totalled $41,610.57 (Table 8). In some of the leases, transportation charges were deducted from the value of the ore before royalties were calculated (GSA, 1981).

The estimated sizes of the individual properties are given in Table 7. These estimates are based on mine maps in Harshbarger (1946) and Coleman (1944); the GSA (1981) production records, and the examination of the old workings by the author in 1953-54. The most productive areas were the Shadyside mines on Plot 3 (Lease 5705) and the Rattlesnake mines on Plot 6 (Lease 5456). Other large mines include the Martin, Eurida, King Tutt Point, and Horse and Hogan mines near Plot 6.

When production, for uranium, resumed in 1948 under the U.S. Atomic Energy Commission's ore procurement programs, the Rattlesnake mines, the Shadyside mines and the mines that were developed on Cove Mesa (Plot 7, Lease 6197) contributed significantly to the uranium production from the Carrizo Mountains (Chenoweth and Malan, 1973). There has been no mining in the Carrizo Mountains since August 1967.

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TABLE 6

Annual Vanadium Ore Production 1942-1947, Carrizo Mountains, San Juan County, New Mexico and Apache County, Arizona.

Year	Tons of Ore	Pounds V_2O_5	Percent V_2O_5
1942	4,079	244,203	2.99
1943	15,504	682,343	2.20
1944	1,820	79,230	2.18
1945	15	582	1.94
1946	0	-	-
1947	15	623	2.08
Total	21,433	1,006,981	2.35

Source: 1942-1945; GSA (1981)
1947; USGS memo dated June 2, 1948 (in DOE files)

TABLE 7

Estimated Vanadium Production, by Mine, 1944-1947, Carrizo Mountains, San Juan County, New Mexico and Apache County, Arizona.

Lease/Mine	Size	Lease/Mine	Size
3798-6197		5456 (cont)	
North Martin	C	Rattlesnake No. 8	B
Martin	A	Plot 13	C
Saytah	B	Plot 14	C
Saytah Canyon	C	Plot 15	C
Main Claim	C	Plot 16	C
Eurida	A	5705	
Cove Mesa	C	Red Wash Point	B
4225		King Tutt Point	A
Sunnyside	B	Shadyside mines	A[2/]
Syracuse	B	Williams Point	C
5456		Fissure	C
Hogan	A	Franks Point	C
Plot 2	C	Lower Oak Creek	B
Plot 3	C	Cottonwood Butte	B
Gila	B	Lone Star	C
Plot 5	C	Oak Springs	C
Rattlesnake mines	A[1/]	White Cap	C
Rattlesnake No. 5	B	Syracuse	C
Plot 8	C	6342	
Plot 9	C	Rattlesnake No. 1	C
Horse	A		
Two Level	B		

Size Class:
A - Great than 800 tons of ore
B - 200 to 800 tons of ore
C - Less than 200 tons of ore

1/ Rattlesnake mines on Plot 6 produced at least 3,500 tons of ore.

2/ Shadyside mines on Plot 3 produced at least 6,000 tons of ore.

TABLE 8

Value of the Vanadium Ore and Royalties, 1942-1946, Carrizo Mountains, San Juan County, New Mexico and Apache County, Arizona.

Lease No. I-149-IND-	Pounds V_2O_5	Total Value	Royalty
3798	127,909.03	$54,380.69	$8,157.09
4225	84,417.95	35,663.08	5,349.48
5465	274,410.63	90,513.96	8,721.35
5705	504,822.27	200,894.37	18,518.77
6197	15,060.28	6,605.69	660.57
6342	361.00	2,257.72	203.31
Total	1,006,981.16	$390,315.51	$41,610.57

Source: 1942-1945; GSA (1981)
1947; USGS memo dated June 2, 1948 (in DOE files)

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